Magnolia portoricensis Bello — Jaguilla

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Magnoliaceae — Magnolia family

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Magnolia portoricensis Bello, known as jaguilla, is an attractive endemic primary forest tree that grows in the central and western upper Cordillera region of Puerto Rico. It is a medium- to large-sized evergreen tree (fig. 1), with dark, shiny, smooth leaves and large, white, aromatic flowers. The abundance and distribution of the species have decreased drastically due to selective harvesting for its valuable wood.

Figure 1.— *Roadside jaguilla tree (*Magnolia portoricensis*) in Carite State Forest, Puerto Rico.*

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HABITAT

Native Range

Jaguilla was formerly an important component of the subtropical wet (*10*) primary forest of the upper central Cordillera region, the Cayey Mountains, and the western serpentine mountains (fig. 2). Prized for its wood, jaguilla was selectively harvested by removing most of the large trees. Although not common, jaguilla is found mainly in State forests of the central and western region of Puerto Rico at Carite, Toro Negro, Guilarte, and Maricao. In the higher mountains of Ciales, Jayuya, and Adjuntas, jaguilla can be found in remote forest areas and in secondary forest stands that have developed from abandoned coffee plantations in which jaguilla had been used to shade coffee. Jaguilla has never been reported in the Luquillo Mountains of eastern Puerto Rico, where *Magnolia splendens* Urban, another endemic magnolia, grows (*4*).

Climate

Jaguilla grows in areas with abundant soil moisture within the subtropical wet life zone (*7, 10*), where mean annual precipitation ranges from 2000 to 4000 mm, and the mean annual temperature is about 22 °C (*5*). In the central region, mean annual precipitation is about 2162 mm, with a relatively dry season of approximately 2 months, generally during January and February. Most precipitation occurs from August to November (*21*). In the western region, much of the rainfall is orographic, averaging 2435 mm annually and generally occurring from April to October, with a 2-month dry period from January to February (*20*).

Soils and Topography

Jaguilla grows in the higher mountains, at elevations ranging from 500 to 925 m. It is found on ridges and slopes, although it thrives best in upland valleys on level sites of volcanic origin. These areas comprise two physiographic

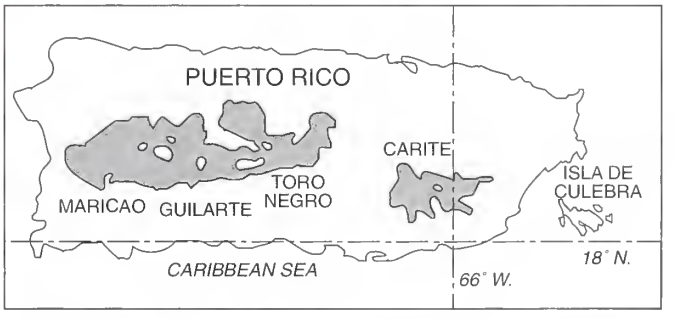

Figure 2.— *Shaded areas indicate the range of jaguilla (*Magnolia portoricensis*) in Puerto Rico.*

units, Monadnocks and St. John Peneplain. These mountains are mainly formed by igneous rock, where highly weathered andesitic rock is the main parent material (*2*). In the western mountains near Maricao, jaguilla grows on areas of serpentine rock of plutonic origin. The soils in these areas are mainly Inceptisols and Ultisols, which are deep, high in clay, medium to low in silt (*3*), moderately well drained, and very strongly to extremely acid (*21*). Abundant soil moisture is typical and may be essential for jaguilla's development.

Associated Forest Cover

The species is an important component of what is known locally as the tabonuco forest. A tree survey made in a remnant primary forest in Ciales with an elevation ranging from 700 to 900 m showed *Dacryodes excelsa* Vahl and jaguilla among the top 10 species with importance values of 5.8 and 5.7 percent, respectively (table 1). *Prestoea montana* (R. Graham) Nichols, a component of the understory, had the highest importance value (21.0 percent). Some other important species were *Alchornea latifolia* Sw., *Buchenavia tetraphylla* (Aublet) Howard, *Eugenia jambos* L., *Ilex sideroxiloides* var. *occidentalis* (Macfad.) Loes., *Matayba domingensis* (DC.) Radlk., *Micropholis chrysophylloides* Pierre, and *Tetragastris balsimifera* (Sw.) Kuntze (author, personal observation).

A survey in an abandoned shaded coffee plantation in the vicinity of Jayuya at an 810-m elevation showed jaguilla growing with *A. latifolia*, *Cecropia schreberiana* Miq., *D. excelsa*, *Inga laurina* (Sw.) Willd., *I. vera* Willd., *Matayba domingensis*, *Michropholis chrisophylloides*, *Ormosia krugii* Urban, and *Schefflera morototoni* (Aubl.) Decne. & Planch. (author, personal observation).

In the Guilarte State Forest, at a 900-m elevation, jaguilla grows in a stand that has a sparse distribution of *Eucalyptus robusta* J. E. Smith and *Pinus caribaea* Morelet. Native species at this site include: *B. tetraphylla*, *Casearia arborea* (L.C. Rich.) Urban, *C. sylvestris* Sw., *Cecropia schreberiana*, *Cordia sulcata* DC., *Dendropanax arboreous* (L.) Decne. & Planch., *I. laurina*, *Ilex sideroxiloides* (Sw. Griseb.), *M. chrisophylloides*, *Pisonia borinquena* ined.,[1] *Prestoea montana*, *Sapium laurocerasus* Desf., and *Schefflera morototoni* (author, personal observation).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.— Jaguilla produces large, fragrant, very showy, white flowers singly at the ends of branches

[1] Proctor, George R. 1994. Personal communication. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

Table 1.—*Relative basal area, relative density, and importance value of tree species in a subtropical wet (10) remnant primary forest in Ciales, Puerto Rico (author, personal observation)*

Species (by importance value)	Relative basal area	Relative density	Importance value
		Percent	
Prestoea montana (R. Graham) Nichols	18.0	24.0	21.0
Micropholis chrysophylloides Pierre	7.9	8.2	8.1
Matayba domingensis (DC.) Radlk.	7.2	7.8	7.5
Tetragastris balsamifera (Sw.) Kuntze	6.6	5.5	6.1
Dacryodes excelsa Vahl	9.8	1.8	5.8
Magnolia portoricensis Bello	7.3	4.1	5.7
Alchornea latifolia Sw.	5.0	5.8	5.4
Eugenia jambos L.	3.7	4.4	4.0
Buchenavia tetraphylla (Aublet) Howard	4.5	3.4	4.0
Ormosia krugii Urban	2.8	4.7	3.8
Cecropia schreberiana Miq.	4.4	2.5	3.5
Schefflera morototoni (Aubl.) Decne. & Planch	3.2	3.5	3.4
Cordia sulcata DC.	3.6	3.0	3.3
Alchorneopsis floribunda (Benth.) Muell. Arg.	2.2	2.5	2.4
Casearia arborea (L.C. Rich.) Urban	1.3	2.1	1.7
Byrsonima spicata (Cav.) HBK.	1.6	1.4	1.5
Inga fagifolia (L.) Willd.	1.8	0.7	1.3
Eugenia confusa DC.	0.6	1.7	1.1
Other species	8.3	12.7	10.6

or in the leaf axils. Flowers are bisexual and hypogynous with an obtuse apex, averaging about 3.0 to 4.5 cm in length. Unlike *Magnolia splendens*, all vegetative parts of jaguilla are glabrous. The androgynoecium is elliptic, about 2 cm long and 1.4 cm in diameter, with numerous pale-yellow pistils 0.62 to 1.25 cm long. Each pistil has a one-celled ovary with two ovules and a curved style, which are spirally arranged on a central axis. Stamens are also numerous, free, and spirally arranged with stout filaments. Stamens measure about 1.3 cm long (*9, 13, 14*). In the western serpentine mountains, jaguilla generally tends to bloom in April, whereas in the central mountains flowering generally occurs from May to November (author, personal observation).

A phenology study conducted in the western serpentine forest showed jaguilla beginning to flower in April, with a peak in May and a rapid decline from June to October.[2] The peak fruiting period also varies with location. In the western serpentine mountains, fruiting occurs from May to November, with a peak from August to October. In the central mountains, the peak fruiting period occurs between October and November (author, personal observation).

The fruit is an aggregate, generally much longer than wide, conelike, greenish, and measuring about 3.5 cm in length and 2.5 cm in diameter (*13*). It is composed of numerous dehiscent carpels, with two red, triangular, fleshy seeds attached to each carpel by threads (*9, 11*). Data gathered in the Maricao State Forest showed that an average of 89 percent of the flowers per tree were successfully pollinated.[3] A sample of fruits collected in November in the Toro Negro State Forest yielded 88 fruits per kilogram (*15*). A sample of 100 fruits of jaguilla collected from the Maricao State Forest showed an average of 18 carpels per cone, with a maximum of 21 and a minimum of 15. An average of 16 carpels had seeds, with a maximum of 20 and a minimum of 9 carpels per cone having seeds. Of those, an average of 12 carpels had 2 seeds and 4 carpels had 1 seed.[4]

Seed Production and Dissemination.—The outer layer of the seed or testa is fleshy, orange, and distinct from the inner lignified seedcoat. The endosperm is plump, oily, and encloses a minute embryo. The endosperm oil content is reported to be over 50 percent in some *Magnolia* species (*11*). A sample of seeds collected from different areas of the central and western mountains had a mean dry weight of 0.135 ± 0.007 g (author, personal observation).

Jaguilla is a good seed producer. Seeds collected from the Toro Negro Forest in 1944 yielded an average of 7,181 fresh seeds per kilogram. Another sample from the same forest yielded 7,592 fresh seeds per kilogram.[5] One study reported a yield of 7,040 to 7,700 seeds per kilogram (*15*). Liberation of seeds occurs gradually. Temperature and moisture influence the opening of fruit carpels and release of seeds. The carpels will gradually split open, making the orange seeds visible. The seeds will hang temporarily by tendrils before falling. Mature fruits can be collected during the months of peak fruit production. The green fruits with partially split openings can be collected from the tree or gathered from the ground.

At room temperature, most fruits collected in Guilarte and Carite State Forests opened 24 to 38 hours after being collected, while carpels of fruit of the same batch set on plastic trays exposed to the sun opened in 8 to 12 hours (author, personal observation). Fruits collected in the Maricao State Forest with carpels partially split open liberated the seeds after 24 hours in a room with controlled temperature (*16*). Seed extraction can be accelerated considerably by drying the fruits with an electric fan.[6]

The aromatic seedcoat and oily endosperm appear to be attractive to birds and rodents. Birds are the principal disseminators of jaguilla seeds (*11*). Seeds eaten by chickens, which were recovered from their manure with no physical injuries to the seeds, showed a germination rate of 90 percent (*16*). Three bird species have been observed consuming jaguilla seeds: llorosa de Puerto Rico (*Nesospingus speculiferus*), zorzal de patas coloradas (*Mimocichla plumbea*), and reina mora (*Spindalis zena portoricensis*).[7] Rodents also consume the fruits for the seeds' oily endosperm; a sample of 500 seeds left overnight on a table in the nursery of the International Institute of Tropical Forestry was totally destroyed by rodents. Seed predation by rodents is probably an important limiting factor in the dispersal of jaguilla.

Seedling Development.—Germination in jaguilla is epigeous; that is, the cotyledons are raised above the soil surface. The author observed that jaguilla seeds germinate readily under the parent trees, except in the Maricao State Forest in the western mountains where natural regeneration is scarce. Generally, a germination boom occurs during the months of peak fruit production. However, no seedling survival has been observed under the crowns of parent trees. Saplings of jaguilla are rarely seen in its natural stands, though they do occur. Generally, saplings grow and develop at a distance from mature trees. The author transplanted 500 wildings collected under 2 adjacent trees in the mountains of Guilarte State Forest to individual nursery bags in a mixture of equal parts of peat moss, sand, and top soil. The survival rate was 90 percent.

In the past, studies have indicated that jaguilla has low

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[2]Padrón, Rubén; Ricart, L. Juan. 1992. Algunos datos florísticos de la jaguilla (*Magnolia portoricensis* Bello). Department of Natural Resources, 18th Symposium of the Natural Resources, November 17-18, 1992. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[3]Padrón, Rubén. 1986. Unpublished data. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[4]Padrón, Rubén. 1986. Unpublished data. Algunos datos florísticos de la jaguilla (*Magnolia portoricensis* Bello). Department of Natural Resources, 18th Symposium of Natural Resources, November 17-18, 1992. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[5]Marrero, José. 1945. Memo 752 dated March 5, 1945. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[6]Marrero, José. 1944. Regeneration, seed studies, *Magnolia portoricensis* Bello. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[7]Padrón, Rubén; Ricart, Juan L. 1992. Algunos datos florísticos de la jaguilla (*Magnolia portoricensis* Bello). Department of Natural Resources, November 17-18, 1992. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

germination. Various reasons have been suggested, including the attack of a cottonlike fungus on the seeds possibly destroying the seed embryos (*6*). In 1978, 800 seeds from the Maricao State Forest and 200 from the Guavate State Forest were completely covered by a fungus, and none germinated (*8*). In 1944, a cutting test on 100 seeds did not show signs of a living embryo.[8] In 1944, a sample of 1,000 seeds collected from the Toro Negro Mountains yielded a 12-percent germination rate (*15*). Another author mentioned that hardly any seeds or seedlings could be found under jaguilla trees and that 30 percent of the seeds failed to develop healthy embryos (*11*). Moreover, even the germination of perfectly developed embryos can be difficult because the seedcoat is impermeable and lignified. It is very likely that the small embryo surrounded by the thick oily endosperm negatively influences the germination of jaguilla (*11*).

Recently, better results have been reported with the germination of jaguilla. In 1977, a light and temperature controlled test yielded a 68-percent germination rate (*8*). In the Maricao State Forest, a germination test was conducted using two different soil mixtures on seeds with and without testae. Seeds with testae yielded 8- and 4-percent germination rates; seeds without testae yielded 80- and 20-percent rates. Sea sand and clay were used in both tests.[9] All seeds with testae suffered fungal attacks.

In 1987, a germination test of seeds from the Maricao State Forest yielded a 90-percent germination rate. In this test the testae had been removed; highest germination occurred in approximately 25 days, and seed viability was lost after 45 days (*16*). In 1991, seeds from the Guilarte State Forest with their testae removed had an 80-percent germination rate. The germination mixture was a sterile commercial mix of peat moss, perlite, and vermiculate. This batch of seeds began germinating on the seventh day (a radicle was observed) with a germination peak at 21 days. The process lasted about 30 days. Generally, jaguilla has been found to germinate well and usually has good numbers of fertile seeds. In a sample of 671 magnolia seeds, 88 percent were fertile (*16*) (author, personal observation). The author's tests showed that jaguilla seeds germinate well, but if the external seed layer is not removed, fungi will invade the seeds damaging the very small, weak embryos. Also, seed viability is reduced with storage time; seeds stored for 20 days failed to germinate.

After germination, most attempts to grow seedlings in nurseries have failed. Seedlings seldom reach more than 10 to 18 cm in height. Yellowing of the leaves, withering, and eventual death is a typical sequence of events, suggesting the absence or limited absorption capacity of a critical nutrient. A local nursery treated two groups of seedlings differently. One group received a 22-4-8 commercial formula of fertilizer and survived about 4 months. The second group was composed of 125 seedlings, 75 of which had been growing for 2 years. This second group received an application of a commercial formula of fertilizer that was high in phosphorus (7-40-6) and a 22-4-8 commercial formula twice a year. Height and diameter at ground line (d.g.l.) averaged 44.47 ± 2.29 cm and 0.51 ± 0.02 cm, respectively. Both groups had a 73-percent shade mesh.

Magnolias need a mychorrizal fungi symbiont for growth in an environment in which phosphorus is limited (*1*). Studies have demonstrated an improvement in phosphorous uptake by the host after vesicular-arbuscular mycorrhizal infection (*17*). Jaguilla, a Magnoliacea, certainly responds to an obligated symbiosis. This association increases the probability of growth and results in better nutrient uptake (*12*).

Vegetative Reproduction.—Jaguilla generally develops shoots as a response to limb breakage; however, new shoot or sucker development is more typical of *M. splendens*. This development has been attributed to recovery after natural disturbances (*14*). Propagation by grafting and stem cutting has not been documented for this species.

Sapling and Pole Stage to Maturity

Growth and Yield.—Jaguilla is a slow-growing, large tree attaining a 22- to 25-m height and a 70- to 90-cm d.b.h. The largest and most valuable trees have been cut. The author measured 43 trees of unknown ages in different areas of the central mountains of Puerto Rico at elevations over 500 m. Heights ranged from 4.0 to 22.4 m, with an average of 14.0 m; d.b.h.'s ranged from 4.7 to 70.3 cm, with an average of 47.3 cm. An inventory of a wet subtropical forest at an 800-m elevation had a basal area for jaguilla trees of 2.37 m^2/ha (author, personal observation). Attempts to establish plantations in open areas under direct sun have failed.

Rooting Habit.—Jaguilla wildings have typical "magnolioid" roots, which are short, thick, and branched, with no root hairs. The roots are generally coarsely ramified so that the youngest roots are generally less than 0.5 mm thick. This type of root (*1*) depends on phosphorous uptake by mycorrhizae, which may enhance the root system's absorbing capacity (*18*).

Reaction to Competition.—Jaguilla is a shade-tolerant tree, found most often in remote, undisturbed areas. It is also found in abandoned coffee plantations, where forest clearing and intensive agricultural practices have had a minimal effect on soils and natural habitats. Jaguilla is a component of the upper canopy. A forest inventory conducted at an 800-m elevation in the central Cordillera ranked it second among dominant trees, preceded by *Dacryoides excelsa*, and sixth among codominants. The survey recorded 45 tree species with a d.b.h. ≥ 9.10 cm per 0.7-ha plot (author, personal observation).

Jaguilla, like *M. splendens*, is associated with forest openings (*22*). Trees never seem to grow in clusters. During the fruiting season, ripening occurs gradually, with seeds continuously falling and germinating under large tree crowns. Seedlings generally survive for only 3 to 4 weeks. Generally, a scant distribution of saplings is found under a closed canopy. The author planted five seedlings at a 550-m elevation in a subtropical wet forest, which originally contained jaguilla. The prepared site, a strip within the forest, measured 1.8 m wide and 10.0 m long, with an open canopy. Weeds were controlled three times per year. After 3 years, two survived and

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[8]Marrero, José. 1944. Regeneration, seed studies, *Magnolia portoricensis* Bello. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

[9]Padrón, Rubén. 1974. Unpublished data. Algunos datos florísticos de la jaguilla (*Magnolia portoricensis* Bello). Department of Natural Resources, 18th Symposium of Natural Resources, November 17-18, 1992. On file with: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-5000.

looked thrifty. They measured 81 and 90 cm in height, and 1.40 and 1.15 cm in d.g.I. (fig. 3).

Damaging Agents.—In its natural range, no serious diseases have been observed, although rodents devour and destroy a large numbers of seeds. In the nursery, seedlings developed yellowish leaves, spindly stalks, and the seedlings eventually died. Hurricane winds generally cause major limb breakage, although the species is resistant to windthrow. Trees tend to recover quickly from hurricanes (author, personal observation). The wood is susceptible to dry-wood termites (*14*).

SPECIAL USES

Jaguilla has a beautiful wood of excellent quality, used mainly for furniture and cabinets. It has a brown sapwood and a yellowish-green heartwood, which is hard and heavy, and has a spicy fragrance and a fine texture. The specific gravity of four samples of oven-dried wood ranged from 0.46 to 0.56 g/cm^3 (author, personal observation). The use of magnolia seed oil as an ingredient for soaps, lotions, and perfumes has been tested with some *Magnolias*, although never with jaguilla.

Figure 3.— *Jaguilla (*Magnolia portoricensis*) sapling planted at Carite State Forest, Puerto Rico.*

GENETICS

Magnoliaceae contains mostly trees and shrubs in about 12 genera and 200 species. This family is naturally distributed in temperate and tropical eastern and southeastern Asia but absent from Europe, Africa, Australia, and Polynesia. In the Western Hemisphere, this family ranges from southern Canada through eastern North America southward through the West Indies and Central America to eastern Brazil (*19*). The chromosome number is 19 (*23*).

In the West Indies, Magnoliaceae is represented by eight native and one introduced species of *Magnolia*, three native species of *Talauma*, and two introduced species of *Michelia*. All naturally occurring *Magnolia* are endemic trees, and all are found at elevations above 500 m. In Puerto Rico, *M. splendens*, closely related to jaguilla, is endemic to the Luquillo Mountains.

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